



Keys to a Successful Monitoring Program: Lessons Learned by the Puget Sound Assessment and Monitoring Program



PSAMP
Steering Committee and
Management Committee



February 2008



The Puget Sound Assessment and Monitoring Program

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Executive Summary

This white paper provides monitoring guidance to the Puget Sound Partnership based on lessons learned by the Puget Sound Assessment and Monitoring Program (PSAMP).

PSAMP is an interagency partnership which evaluates the condition of Puget Sound and its resources. This network of regional scientists monitors key indicators of water and sediment quality, nearshore habitat, shellfish beds, and the health of fish, seabirds, and marine mammals. PSAMP scientists documented many of the serious problems facing Puget Sound today, including:

- The extent and magnitude of toxic contamination in fish and sediments.
- Low dissolved oxygen in Hood Canal and South Puget Sound waters.
- Serious declines in marine birds, fishes and other biological resources.
- Changes in harvest conditions in shellfish beds.
- The extent of bulkheading and other shoreline alteration.
- Eelgrass declines in the San Juan Archipelago and Hood Canal.

PSAMP's strengths include scientific programs that monitor a diverse set of long term indicators and strong coordination. PSAMP's key weaknesses lie in its links to management: the program is limited primarily to status and trends monitoring and management roles are not well defined.

During almost twenty years of monitoring, PSAMP has learned what features are most important for a successful regional monitoring program. A successful program could be developed under a variety of potential governance structures, as long as that structure provides the following necessary organizational attributes and technical elements:

Organizational attributes:

A **comprehensive** ecosystem-scale strategy is needed that is agreed upon by all participants. Monitoring must be **integrated** across disciplines and across terrestrial, freshwater, estuarine, and marine ecosystems. **Clearly defined** roles will promote efficiency and accountability. An **inclusive** approach will attract the willing participation of a broad range of stakeholders.

While adaptive management requires tight linkages between scientists and managers, scientific independence and rigorous peer review are essential to **credible and objective** monitoring results. Regular evaluations are needed to ensure that activities are **efficient and cost effective**.

Technical Elements Needed in a Regional Monitoring Program

- **Clear monitoring objectives** derived from clear management goals through ecosystem-based assessment.
- **Integrated monitoring, research and modeling activities**, implemented at appropriate scales.
- **A set of key ecosystem indicators** to gauge progress.
- **A quality assurance program** that produces credible, objective, and verifiable data.
- **A data management approach** that assures data can be easily accessed.
- **Communication and outreach** of results produced regularly for a variety of audiences.
- **Regular, external programmatic evaluation** to assure that the program is on-track.
- **Stable funding and infrastructure** to consistently collect, analyze and synthesize data.

Introduction

The newly established Puget Sound (PS) Partnership is leading efforts to restore Puget Sound by 2020 (RCW 90.71.200). The enabling legislation mandates central roles for science and monitoring – the PS Partnership will develop an Action Agenda that bases decisions on science and includes clear, measurable goals. Additionally, the PS Partnership shall determine accountability for actions, ensure efficient implementation, engage the public, and track results. These elements require comprehensive and coordinated science and monitoring.

The purpose of this white paper is to provide guidance to the PS Partnership based on lessons learned during two decades of monitoring by the Puget Sound Assessment and Monitoring Program (PSAMP). The white paper describes PSAMP, analyzes its strengths and weaknesses, and identifies essential features of a comprehensive program. Our recommendations are based on approximately twenty years of experience in tracking the status of valued ecosystem components and characterizing the extent and magnitude of threats to Puget Sound.

PSAMP Description

Program Structure

PSAMP is an interagency partnership formed to assess status and trends in the condition of Puget Sound and its resources. It was established in 1988 as a consortium of scientists and managers that includes representatives from state, federal, and county agencies and the University of Washington. The PS Partnership recently assumed management responsibility of PSAMP and other activities that were previously administered by the Puget Sound Action Team (PSAT).

PSAMP was designed by the Puget Sound Water Quality Authority's 35-member Monitoring Management Committee, with guidance from a 21-member Technical Advisory Committee. Its scope is originally defined in The Puget Sound Water Quality Protection Act to include, at a minimum:

1. A research program, including but not limited to methods to provide current research information to managers and scientists, and to establish priorities based on the needs of the action team;
2. A monitoring program, including baselines, protocols, guidelines, and quantifiable performance measures. In consultation with state agencies, local and tribal governments, and other public and private interests, the action team shall develop and track quantifiable performance measures that can be used by the governor and the legislature to assess the effectiveness over time of programs and actions initiated under the plan to improve and protect Puget Sound water quality and biological resources..." (RCW 90.71.060 prior to amendment in Laws of 2007, Chapter 341)

While the original scope of PSAMP was comprehensive, the current scope of PSAMP is substantially more limited due to funding constraints. PSAMP's primary mission is to monitor long-term status and trends of key ecosystem indicators and to conduct targeted assessments. PSAMP's core activities consist of eight key topic areas (Table 1). This suite of activities was

identified at the time of PSAMP’s establishment to address gaps in existing monitoring programs and to capture long-term indicators of environmental health.

PSAMP activities are defined in the biennial Puget Sound Conservation and Recovery Plan and supported with state funds allocated by the legislature. In addition, federal, state and local agencies contribute separate funds to bolster activities, including the University of Washington (UW), King County, US Environmental Protection Agency (EPA), US Fish and Wildlife Service (USFWS), and the National Oceanographic and Atmospheric Administration (NOAA).

Table 1. PSAMP Components and Lead Agencies

Component	Agency
Sediment and benthic habitat quality	Wa. Dept. of Ecology, King County
Toxic contaminants in fish and shellfish	Wa. Dept. of Fish and Wildlife, NOAA Fisheries
Nearshore habitats	Wa. Dept. of Natural Resources
Abundance of key marine fish resources	Wa. Dept. of Fish and Wildlife
Abundance of key marine bird species	Wa. Dept. of Fish and Wildlife US Fish and Wildlife Service
Marine water quality	Wa. Dept. of Ecology, King County, University of Washington
Shellfish harvest bed conditions	Wa. Dept. of Health
Freshwater quality	Wa. Dept. of Ecology

Scientists and managers representing participating agencies serve on PSAMP coordination committees, known respectively as the Steering and Management Committees. A science coordinator from the PS Partnership (formerly PSAT) provides staff support, serves as the PS Partnership liaison, and represents PSAMP externally. Agency participation in the Steering and Management Committees is mandatory as part of the funding obligations. Additionally, several agencies participate voluntarily to take part in coordinated, sound-wide scientific activities.

As directed in the enabling legislation, PSAMP scientific findings are integrated and summarized bi-annually in the *Puget Sound (PS) Update*, which serves as a technical support document for the *State of the Sound* report. PSAMP scientists also take part in organizing the *Puget Sound/Georgia Basin Research Conference*, which includes chairing sessions, and presenting talks and posters.

PSAMP regularly engages in 5-year program-wide reviews, including a six-month review in 1995 by a commissioned external panel. These reviews identified important course adjustments for PSAMP at levels ranging from program-wide issues to sampling design for individual components. Each review identified the pressing need to strengthen linkages between PSAMP science and management objectives, and to integrate PSAMP science within a comprehensive ecosystem framework (see appendix for 1995 and 2005 review findings and recommendations.)

Key Findings

PSAMP evaluates the health of the Sound through indicators, surveys, and special studies. Because monitoring has been conducted with consistent standards and protocols, the studies have succeeded in identifying long-term, regional patterns in ecosystem components and changes in biological and physical resources. The PSAMP monitoring components are summarized in the appendix.

PSAMP monitoring provides a system to raise awareness of emerging environmental problems. Since its establishment, PSAMP scientists have documented many of the serious problems facing the Puget Sound today, including:

- Low dissolved oxygen in Hood Canal and South Puget Sound waters;
- The extent and magnitude of toxic contamination in fish and sediments;
- Serious declines in marine birds, fishes and other biological resources;
- Changes in harvest conditions in shellfish beds;
- The extent of bulkheading and other shoreline alteration;
- Eelgrass declines in the San Juan Archipelago and Hood Canal.

PSAMP scientists have also led substantial research into the causes and solutions to these problems.

While the general scope of PSAMP work has been to conduct long-term, basin-wide status and trends monitoring, there are many examples of how PSAMP activities have been integrated into local and regional management activities, including:

- **Fecal coliform pollution in shellfish growing areas** – identifies threatened shellfish beds by considering fecal coliform status and trends. In areas identified as threatened, dialogue and action begin at the local level to identify and control pollution from nonpoint sources. Ongoing monitoring evaluates success of remedial activities in the uplands.
- **Marine water quality** – assesses overall health for statewide Clean Water Act assessment (303d) and reporting (305b); provides baseline data for studies and modeling efforts to determine current water quality, and effects of human activity and natural stressors over time; identified low dissolved oxygen in Hood Canal and informs ongoing studies; contributes to Total Maximum Daily Loading (TMDL) studies.
- **Nearshore habitat inventories** – used extensively in local shoreline plans, regional recovery plans such as the Shared Strategy for Salmon Recovery, restoration by the Puget Sound Nearshore Partnership, and ecoregional assessments by the Nature Conservancy.
- **Conservation actions and regulations to protect declining fish and wildlife species**— results from surveys and analyses are used by the Department of Fish and Wildlife to develop Conservation Plans and set seasons and fishing limits.
- **Marine sediment quality** – assesses sediment quality for statewide Clean Water Act reporting; baseline for sediment loadings studies; large-scale data for comparison to site-specific regulatory cleanup work.
- **Toxic and contaminants in fish** – used by the Department of Health to develop health advisories related to consuming seafood from Puget Sound.

PSAMP serves as an information source for managers, politicians, tribes, non-governmental organizations (NGOs) and the media on environmental conditions in Puget Sound. PSAMP results have also informed local watershed management groups, remedial action programs, and marine resource committees. News reporters regularly cover PSAMP projects and findings, including the

Seattle Post-Intelligencer's award-winning series *Our Troubled Sound*. In addition, scientists regularly publish results in journals, books, and peer-reviewed reports.

The first *Puget Sound Research Conference* was convened in 1991 to provide a forum for sharing regional research related to science and management. PSAMP investigators take part in conference organizing and are major contributors. The bi-annual conferences have grown steadily since their inception. In 2003, the conference expanded to include the Canadian Georgia Basin. In 2007, over 900 attendees represented a wide range of scientists, and managers from federal, state/provincial, tribal, and non-governmental organizations. In addition to building connections across disciplines and organizations within Washington State, the conferences and coordinated monitoring efforts have fostered strong transboundary connections between British Columbia and Washington.

In response to the 1995 program review recommendations, PSAMP developed a conceptual model that identifies and describes interactions between important ecosystem components, human activities, and stressors in the Puget Sound ecosystem. Since its completion, the conceptual model has been used by other groups as a broad framework for understanding ecosystem components and threats in the region. Examples include two efforts led by NOAA, a risk analysis for Puget Sound and an indicator development work group, which will inform the PS Partnership about threats to ecosystem health and candidate indicators.

PSAMP's Strengths and Weaknesses

PSAMP's organizational structure has profound strengths that should be conserved and important weaknesses that should be addressed in future monitoring governance:

- ***PSAMP monitors a diverse set of long term indicators. Because work is limited to status and trends monitoring, links to management actions are indirect.***

PSAMP monitors a highly diverse set of environmental indicators. As a result, it provides information on the condition of many different aspects of Puget Sound's health. Its broad scientific span also fosters an ecosystem-based perspective. However, PSAMP governance lacks a comprehensive framework or model that defines monitoring and assessment activities within the context of management, protection, and restoration activities.

PSAMP's currently funded tasks fall short of the scope envisioned in the enabling legislation. In addition to monitoring, the statutory mandate included a research program and performance measures to assess the effectiveness of programs and actions. These limitations are the most serious barriers to integration of science and management. Inclusion of implementation, compliance, effectiveness, and validation monitoring would tighten linkages to management actions. Socio-economic issues, although not defined in PSAMP's original goals, are also critical to comprehensive monitoring. The 1995 and 2005 program reviews also recommended expansion of PSAMP's program scope.

- ***The interagency structure encourages organizational integration. Conflicts sometimes occur between the interagency program and individual agencies.***

PSAMP's governance model links multiple agencies that implement monitoring through a central coordinating agency. This structure encourages connections between agency management and

monitoring activities through organizational integration. It has the potential to foster even closer links to agency activities if program effectiveness monitoring were included. Tight coordination with agencies is most important for programs that monitor management success (ie., through implementation, compliance, effectiveness, and validation monitoring). Status and trends monitoring also has management linkages in many cases, since many agencies are explicitly mandated to wisely manage resources.

One risk of housing monitoring within agencies is the potential for a conflict of interest. PSAMP has experienced two types of conflicts:

- Conflicting organizational priorities - implementing agencies have occasionally decreased or redirected funding intended for PSAMP monitoring. Resolving these conflicts is critical to maintaining comprehensive long-term monitoring.
- Independence of science – on one occasion, managers in the coordinating agency re-interpreted and changed the portrayal of monitoring results in the *State of the Sound* report without consulting the scientists. Incidents such as this seriously threaten program credibility, as well as undermining trust. Independent scientific reporting is critical to building trust in scientific results.

➤ ***PSAMP fosters strong coordination across scientific disciplines and across organizations. Coordination with managers has been limited by a poorly defined role for management.***

One of PSAMP's greatest strengths is that it fosters strong coordination across state, federal, academic and local organizations. Coordination occurs at the implementing program level through the Steering and Management Committees. Committee activities include identifying biennial science tasks that meet the needs of the Puget Sound Conservation and Recovery Plan, coordinating budget requests, tracking status on tasks, and reporting on scientific findings. The committees also provide a forum for scientific coordination, including shared sampling resources, protocol usage, and data interpretation. Over time, PSAMP scientists and managers have built an extensive network of regional specialists who collaborate and share information. While PSAMP is very successful at informal coordination, a framework is needed for formalizing interactions among regional monitoring entities, including the Washington Forum on Monitoring, the Puget Sound Monitoring Consortium, and the Pacific Northwest Aquatic Monitoring Program. PSAMP would also benefit from expanding its formal collaboration with tribes, non-governmental organizations, and citizens' groups.

Since its inception, PSAMP has worked to build strong links between science and agency management. Both the 1995 and the 2005 program reviews strongly recommend strengthening the linkage between monitoring and management. The PSAMP Management Committee was formed to promote such connections. However, this effort has only been moderately successful. More explicit linkages between monitoring and management activities would significantly increase cooperation between these groups.

➤ ***Funding provisos have generally succeeded, but low funding levels have limited data collection and synthesis.***

PSAMP's funding mechanism develops coordinated budget items that appear in both implementing agency budgets and the Puget Sound Conservation and Recovery Plan. As part of plan approval, the legislature assigns budget provisos to core PSAMP activities to ensure that

funds are devoted to monitoring. In most cases, the proviso approach has been highly successful. In some cases, individual agencies have re-directed funds from traditional monitoring activities to other agency priorities. When individual agency funding priorities differ from interagency funding needs, a mechanism is needed for resolving conflicts and ensuring the continuity of long-term monitoring needs.

Long-term funding is often challenged by short-term, high priority needs. PSAMP's budgets have generally decreased over time due to budget cuts, overhead increases, and inflation. In addition, funds have been unavailable for PSAMP to address recommendations from program reviews. Faced with these limitations, groups have secured external funds, collaborated with other groups to reduce costs, or discontinued portions of their monitoring. Typically, external funding is applied to studies that expand upon PSAMP findings to further investigate observed trends, rather than to maintenance or expansion of underlying long-term monitoring.

➤ ***Program resources and staff support are crucial to success, and they have decreased over time.***

Since its inception, the coordinating agency has provided staff support to PSAMP. The primary position was initially a Chief Scientist, it is now a Program Coordinator who works closely with the PSAMP Principal Investigators (PIs). The 1995 program review found that the roles of the Chief Scientist and PIs were unrealistically broad, which hindered data synthesis. It recommended that funds be dedicated specifically to data interpretation, data management, and program coordination. Unfortunately, since the 1995 review resources have decreased rather than increased. PSAMP activities are now a minor responsibility for the Program Coordinator. With the exception of the *PS Update*, individual agencies are responsible for virtually all PSAMP communications and reporting. These resource limitations have severely hindered ecosystem-level analysis and strategic program planning.

Data management is another area in which significant improvements are needed in order to ensure future program success. Within PSAMP, the coordinating agency initially intended to centralize data management. Because centralized data management was never implemented, the implementing agencies took responsibility for data management and distribution. The agencies currently provide a relatively stable environment for consistently collecting, maintaining and integrating long-term datasets. Technological innovations in data management and data sharing have likely outmoded the concept of centralized data management. Future data management efforts should adopt a flexible, distributed data model that prioritizes data sharing. Substantial expertise and resources will be required to meet the PS Partnership's goals for sharing data and information.

The *Puget Sound/Georgia Basin Research Conference* is an example of a highly successful use of program resources to link scientists and managers throughout the region. This conference is now the premier regional science and monitoring forum. It would not be possible without the organizational efforts of the coordinating and implementing agencies.

Conclusions: Features of a Successful Monitoring Program

PSAMP provides a successful model for long-term, multi-party, coordinated monitoring. PSAMP scientists were among the first to identify and document many of the serious problems facing Puget Sound today, and they continue to provide core data and original results focused on understanding both the status of the Puget Sound ecosystem and its major threats.

During almost twenty years of monitoring, PSAMP has learned what organizational features and what technical elements are most important for a successful regional monitoring program. We believe that a successful monitoring program could be developed under any one of a variety of potential governance structures, so long as that structure supports and provides the necessary organizational features and technical elements listed below.

Organizational Attributes Needed in a Successful Regional Monitoring Program

Comprehensive

- a. Guided by a broad, ecosystem-scale strategy agreed to by all participants,
- b. Supports the PS Partnership's Action Agenda and adaptive management goals,
- c. Considers monitoring and assessment in the context of management, protection, and restoration,
- d. Accounts for the needs of humans as well as other species.

Integrated

- a. Links marine monitoring with terrestrial, freshwater, estuarine, and watershed studies,
- b. Coordinates across scientific disciplines, including physical, biological, chemical and socioeconomic sciences,
- c. Connects ambient and regulatory monitoring where appropriate,
- d. Makes scientists, managers and stakeholders core members of the program.

Clearly Defined

- a. Defines roles and relationships among all parties, including who is accountable (and for what), how decisions are reached, how disagreements are resolved, and how resources are allocated,
- b. Establishes management goals and targets for participating stakeholders to design and assign monitoring strategies that will evaluate effectiveness ,
- c. Recognizes the unique information needs, goals, and mandates of organizations.

Inclusive

- a. Attracts the willing participation of multiple entities, including agencies, local governments, tribes, universities, businesses, NGOs, and citizens,
- b. Recognizes and builds upon the successes and collaborations of existing programs and partnerships,
- c. Fosters coordination and collaboration among existing and new participants.

Credible and Objective

- a. Builds credibility through collaborative development of monitoring approaches, sampling designs, and protocols, especially between regulatory agencies, regulated industries, and NGOs,
- b. Establishes agreed protocols, and methods,
- c. Accountable to scientific rigor through peer review.

Efficient and Cost Effective

- a. Partners at local, tribal, state, federal, and transboundary levels so that resources can be pooled and efficiencies gained,
- b. Regularly evaluates methods to optimize work.

Technical Elements Needed in a Regional Monitoring Program

To be successful, a coordinated, regional monitoring program must have:

1. **Clear monitoring objectives** derived from clear management goals through ecosystem-based assessment
2. **Integrated monitoring, research and modeling activities**, implemented at appropriate scales, including:
 - a. Status and trends monitoring
 - b. Compliance and effectiveness monitoring
 - c. Implementation and validation monitoring
 - d. Cause-and-effect studies
 - e. Process and landscape models to synthesize monitoring and provide feedback
 - f. An adaptive management framework that targets restoration and conservation activities which improve environmental condition
3. **A set of key ecosystem indicators** to gauge progress toward the goal of restoring the Puget Sound ecosystem.
4. **A quality assurance program** that produces credible, objective, and independently verifiable data.
5. **A data management approach** that makes data easily available through an information sharing network.
6. **Communication and outreach** of monitoring results produced for a variety of audiences in a regular and timely manner.
 - a. Web-accessible data and information.
 - b. Regular reporting for managers, political leaders, the public, and stakeholders.
 - c. Scientific interactions through professional papers, conferences, and workshops.
7. **Regular, external programmatic evaluation** to assure that the program is on-track.
8. **Stable funding and infrastructure** to consistently collect, analyze and synthesize data.

Appendices

1995 PSAMP Review: Panel Findings and Recommendations

From *Panel Findings and Recommendations Based on the First Comprehensive Review of the Puget Sound Ambient Monitoring Program*. G.T. Shen. December 1, 1995.

- Finding: Expansion of PSAMP's underlying goals and questions is needed to impart to the program a "big-picture" vision directed towards protection of the Puget Sound ecosystem.
- Recommendation: PSAMP should develop ecosystem and management conceptual models which incorporate stressors, key processes, and linkages.
- Finding: Management influence within PSAMP has declined since the program's inception. Current management linkages vary greatly among monitoring tasks.
- Recommendation: Management goals and acceptable levels of uncertainty for decision-making must be clearly stated. PIs and management stakeholders must maintain an active dialogue.
- Finding: PSAMP is managed by essentially the same individuals who perform the monitoring. The program lacks an institutional structure that can ensure a senior policy commitment and program-wide coordination.
- Recommendation: Program coordination should be improved by reorganizing along several committee levels which incorporate broad agency and citizen representation.
- Finding: The PSAMP program is too rigidly defined according to monitoring tasks. Historically, linkages between tasks have largely risen via informal discussion between PIs.
- Recommendation: PSAMP must function not as individual tasks, but as a collection of interwoven components of a larger program.
- Finding: Over five years of monitoring, PSAMP has not accomplished its original goal of integrating monitoring data on a Puget Sound-wide basis in order to assess comprehensively, the state of Puget Sound.
- Recommendation: PSAMP should take the lead in establishing regular comprehensive surveys of monitoring efforts going on throughout Puget Sound.
- Finding: The roles of PSAMP PIs and Chief Scientist have been unrealistically broad. As one of many consequences, data synthesis has lagged and held back the program.
- Recommendation: Funds must be dedicated specifically to data interpretation and data management. Sampling and analysis are pointless if there is inadequate commitment to understanding the data. PI responsibilities for data interpretation, data management, program coordination, and program output must be redistributed amongst an expanded staff. The Chief Scientist should operate more as a program coordinator and receive assistance for all technical aspects.

2005 PSAMP Review: Findings and Recommendations

From *2005 Review of the Puget Sound Ambient Monitoring Program Final Report*, PSAMP Management Committee, October 20, 2005.

Review Question	Finding
1. How well does PSAMP assess the health of Puget Sound?	PSAMP is very successful in its primary mission of delivering data and analysis for the assessment of the health of Puget Sound. Examples include: <ul style="list-style-type: none">• oxygen depletion in Hood Canal;• contaminants in sediments and the marine food web.
2. How well does PSAMP assess the success of management strategies?	<ul style="list-style-type: none">• Generally PSAMP does not assess implementation or effectiveness of specific management strategies, particularly at the local scale;• DOH shellfish component is very effective in assessing specific corrective actions;• PSAMP effectively assesses cumulative environmental outcomes of management actions at the regional scale.
3. How well does PSAMP fill science gaps to help develop management actions?	<ul style="list-style-type: none">• Limited focused research addresses specific management questions or corrective actions;• Studies do not have dedicated funding;• Studies not comprehensively meeting management needs.
4. How well does the current governance structure of PSAMP function?	<ul style="list-style-type: none">• Linkages between management and PSAMP research need to be strengthened.

Overall Recommendations

1. Strengthen connections between PSAMP, the Puget Sound Action Team and Puget Sound Council
 - Directly coordinate PSAMP with the State of the Sound Report.
 - Create process to regularly report scientific findings to PSAT and Puget Sound Council and trigger the development of action plans.
 - Include science advice in strategic management actions in marine and estuarine waters
 - Increase coordination between PSAMP Steering and Management Committees and the Management Team of the Puget Sound Action Team.

2. Strengthen connection between the Puget Sound Ambient Monitoring Program and key external entities and processes including:
 - Governor’s Monitoring Forum and Comprehensive Monitoring Strategy.
 - Puget Sound Ecosystem-Based Management (lead by Northwest Fisheries Science Center).
 - Puget Sound Nearshore Program.
 - Shared Strategy Salmon Recovery Plan.
 - Develop budget requests as part of local, state and federal processes that include assessment, monitoring and accountability.

3. Expand the scope of the Puget Sound Ambient Monitoring Program (adopt new name Puget Sound *Assessment* and Monitoring Program).
 - Expand role to include ambient, effectiveness and validation monitoring and other assessment monitoring.
 - Expand role to providing science advice (adopt new name Puget Sound Science Advisory Work Group).
 - Identify gaps in science for Puget Sound Conservation and Recovery.
 - Conduct scientific review of monitoring and assessment proposals.
 - Expand participation on PSAMP Steering and Management Committees to all relevant monitoring and assessment programs that contribute to the Health of Puget Sound. assessment, Puget Sound Conservation and Recovery Plan, and potentially Puget Sound Initiative.
 - Include currently non-represented state and federal monitoring programs.
 - Include Sea Grant and other university programs.
 - Include tribal government efforts.
 - Include local government and NGO efforts.

Descriptions of PSAMP Monitoring Components

Fecal Coliform and Paralytic Shellfish Poisoning Monitoring

Shellfish Program, Washington Department of Health

<http://www.doh.wa.gov/ehp/sf/default.htm>

Purpose/Questions Addressed:

- DOH determines for PSAMP the status and trends in fecal coliform pollution in Puget Sound shellfish growing areas.
- DOH also evaluates spatial and temporal patterns in biotoxin concentrations in mussels at over 30 points in Puget Sound.

Approach:

For PSAMP DOH uses data collected from two underlying shellfish monitoring activities and applies separate graphic and statistical methods designed to identify status and trends.

Indicator Uses:

- For the fecal coliform component, DOH uses fecal coliform data (as “most probable number per 100ml of water”) used to classify shellfish growing areas according to suitability to harvest shellfish.
- For the PSP component, PSP data collected from a sentinel “mussel watch”-type program to provide early warning of the onset of blooms of harmful biotoxin-producing algae are adapted to graphic analysis of patterns.

Related Regulations, Policies, and Initiatives:

The underlying programs serve to allow DOH to accomplish its mandate to protect shellfish consumers from eating shellfish bearing either pathogens or biotoxins. Fecal coliform status and trends analyses allow Shellfish Protection Districts (RCW 90.72) to evaluate their efforts to reopen shellfish beds closed due to nonpoint pollution. Under the Puget Sound Plan, DOH annually provides a list of shellfish growing areas threatened with closure due to pollution. Fecal coliform status and trends help determine what areas should be considered *threatened*. Once an area is determined to be threatened, dialogue and action begin at the local level to identify and control pollution from nonpoint sources.

Major Accomplishments:

From the beginning the DOH analysis for PSAMP has provided a tool for regulators, planners, and policy makers at all levels (local, tribal, and state) to evaluate changes in pollution in shellfish beds. The results also aid in evaluating the success of remedial activities in associated uplands.

Groundfish Monitoring and Assessment

Washington Department of Fish and Wildlife

<http://wdfw.wa.gov/fish/management/>

Purpose/Questions Addressed:

The three main purposes are to determine the status of groundfish populations in Puget Sound, develop conservation plans promoting population and fishery sustainability, and monitor and analyze the efficacy of marine reserves groundfish populations in Puget Sound.

Approach:

WDFW uses a combination of fishery-dependent and fishery-independent data sources to determine the long-term trends and present status of groundfish populations in Puget Sound. Fishery-dependent information includes catch, effort, and biological data obtained from recreational and commercial fisheries in Puget Sound. Resource surveys using diving, bottom trawls, and remote optical tools confirm or independently determine the status of rockfish, lingcod, flatfish, dogfish, and cod populations in Puget Sound. We also use focus studies on existing WDFW Marine Protected Areas to understand the effect of fishing on long-lived species such as rockfish and lingcod.

Indicator Uses:

Information resulting from groundfish monitoring is synthesized into analyses and, when possible, demographic models of population abundance. Rockfish and other groundfish population trends and the proportion of groundfish stocks in healthy or poor conditions have been used in the State of the Sound, the *Puget Sound Update*, and WDFW management plans to inform managers and tribal co-managers.

Related Regulations, Policies, and Initiatives:

Groundfish populations are managed for non-tribal citizens under the auspices of the Puget Sound Groundfish Management Plan that calls for the development of Conservation Plans for key groundfish species. Groundfish assessments have pointed to declining populations of rockfish, spiny dogfish, and Pacific cod and have prompted fishery closures and other regulations to lessen direct fishing impacts in both recreational and commercial fisheries.

Major Accomplishments:

- Majority of groundfish populations have improved and are in good condition.
- Remotely-operated vehicles were found to be useful tools for assessing rocky habitat species in Puget Sound.
- Peer-reviewed papers about the effect of hypoxia on fishes in Hood Canal and on dogfish populations.
- Improved lingcod population through continued conservative management.
- Targeted fisheries have been removed on rockfishes.
- Marine Protected Areas may be a tool to conserve lingcod and rockfish.

King County Marine Monitoring

King County Department of Natural Resources & Parks

<http://dnr.metrokc.gov/wlr/waterres/marine/>

Purpose/Questions Addressed:

- Characterize spatial and temporal trends in both subtidal and intertidal ambient marine waters within King County. Characterize temporal trends in marine sediments.
- Assess water and sediment quality at King County wastewater treatment and CSO marine outfalls.
- Assess monitoring data in relation to applicable water and sediment quality guidelines.
- Comply with NPDES sediment monitoring requirements.
- Bioaccumulation of pollutants in bivalve tissues.
- Determine physical & chemical dynamics that influence water quality.

Approach:

- Samples are collected from both ambient and point-source locations located throughout King County marine waters. Some locations are targeted for specific parameters (such as bacteria in water) and other locations sampled as part of a long-term dataset. In general, sampling program includes: Monthly water column and intertidal samples analyzed for a variety of chemical and physical parameters.
- Ambient subtidal and intertidal sediment samples analyzed for pollutants on a 5-yr rotational basis. Elliott Bay subtidal sediments analyzed on a 2-yr cycle.
- Benthic community analysis at wastewater treatment plant outfalls.
- Semi-annual butter clam tissue sampling.

Indicator Uses:

Marine water quality index, KingStat environmental indicators, regulatory compliance, effectiveness monitoring, long-term trends

Related Regulations, Policies, and Initiatives:

NPDES permit program, ESA long-term sediment monitoring requirements, WDNR outfall lease requirements, HPA permit requirements, 303(d) list, King County's Sediment Management Program, King County Puget Sound Ordinance, PSAMP.

Major Accomplishments:

- Secured funds for high-frequency monitoring systems and installment of two moorings.
- Increased monitoring in sensitive areas.
- Implemented web-based downloadable database.
- Released water quality status report, including trend analysis for monitoring data, and various other data assessment reports.
- Continued long-term monitoring program dating back to the 1960s.

Marine Bird and Mammal Research, Monitoring, and Assessment

Washington Department of Fish and Wildlife

<http://wdfw.wa.gov/mapping/psamp/>; <http://wdfw.wa.gov/wlm/psamp/scoters/index.htm>;

<http://wdfw.wa.gov/science/>; <http://wdfw.wa.gov/wildlife.htm>

Purpose/Questions Addressed:

Marine birds and mammals are used as indicator species because of their ubiquity, their broad diet, and their collective vulnerability to a range of human activities. Questions addressed:

- *Is there a change in the distribution and abundance of indicator species?*
- *What are the contaminant levels in marine mammal tissues and how might these contaminant levels effect successful reproduction and survival?*
- *Has the diet of important indicator species changed over time?*

Approach:

- **Marine bird and mammal population trends-** Annual winter bird sampling to compare abundance between years and locations. Aerial photographs of haulouts to assess trends.
- **Contaminant levels in marine mammal tissues and how these contaminant levels effect successful reproduction and survival-** Tissues were collected from harbor seals in the Sound and Strait and levels of persistent organic pollutants were compared using a food basket approach.
- **Diet change of important indicator species over time-** Comparing the quality and composition of today's seabird diet with data collected in the 1970's to examine potential mechanisms for bird declines.

Indicator Uses:

- Assess species status under the State and Federal endangered species acts.
- Examine the spatial overlap between proposed development projects (e.g., tidal and wave energy projects) and the distribution of wildlife species.
- Identify the factors (e.g., diet, contaminants, disturbance, etc.) that limit wildlife populations and to focus conservation actions.
- Determine whether marine mammal population levels and trends are consistent with management criteria under the Marine Mammal Protection Act.
- Modify fishing activities to minimize impacts to wildlife. Modify waterfowl hunting limits.
- Assess impact of oil spills or other chemical spills on wildlife.
- Focus oil cleanup activities to provide greatest benefit to wildlife species.

Major Accomplishments:

- First spatially explicit marine bird monitoring scheme.
- First repeatable, baseline population estimates for several bird species.
- Assessed occupancy of historic tufted puffin nesting sites.
- Harbor seal contaminant levels exceeded guidelines for wildlife consumption.
- Created seal and sea lion haulout site atlas.
- Limiting factors are being studied (e.g., diet, contaminants).
- Creation of the marine bird density atlas (<http://wdfw.wa.gov/mapping/psamp/>)

Marine Sediment Monitoring

Environmental Assessment Program, Washington Department of Ecology

www.ecy.wa.gov/programs/eap/psamp/index.htm

Purpose/Questions Addressed:

The PSAMP Sediment Component provides spatial and temporal characterization of sediment quality conditions in Puget Sound.

Approach:

- **Spatial characterization** – A minimum of 30 stations are sampled each year using a probabilistic sampling design, allowing calculation of the total area (km²) of sediment quality degradation in the current study area (bay-, region- and/or Puget Sound-wide scale).
- **Temporal characterization** – Sediment chemistry and benthic invertebrate data from 10 long-term Puget Sound stations are analyzed for changes over time. In addition, bay-, region- and Puget Sound-wide spatial estimates of sediment quality degradation are examined for changes over time.

Indicator Uses:

- **Sediment chemistry, toxicity, and benthic infauna data** - compared against **state and national sediment quality guidelines**, and are combined in the **Sediment Quality Triad Index**.
- **Cumulative Distribution Function (CDF)** - determines the percent of the study area that is degraded, and used to determine change in percent degradation over time.
- **Trend analyses** - changes in contaminant levels and benthic infaunal indices over time at long-term stations.

Related Regulations, Policies, and Initiatives:

1) Baseline sediment data for others, 2) large-scale perspective for site-specific regulatory cleanup work, 3) sediment quality assessment listings (303d, Clean Water Act), 4) Ecology's Urban Waters Initiative, 5) baseline for Ecology's sediment loadings study, 6) Puget Sound Initiative.

Major Accomplishments:

- **the past 2 years:**
 - Characterizing 1) changes and trends in Puget Sound sediment quality from 10 long-term stations, 2) relationships between sediment quality, dissolved oxygen, and benthic invertebrate communities in Hood Canal, and 3) PBDE levels in Puget Sound sediments.
- **the past 5 years:**
 - Estimating the spatial extent (km²) of sediment quality degradation in 8 regions, Sound-wide.
 - Development of the Sediment Quality Triad Index for Puget Sound.
- **since 1989 (18 years):**
 - Established of high quality spatial and temporal baseline sediment data throughout Puget Sound.
 - Over 40 reports, posters, and presentations summarizing Puget Sound sediment conditions.

Marine Waters Monitoring – Washington State

Environmental Assessment Program, Washington Department of Ecology

http://www.ecy.wa.gov/programs/eap/mar_wat/mwm_intr.html

Purpose/Questions Addressed:

What are the spatial & temporal patterns in water quality in the marine waters of Puget Sound and the coastal estuaries? Are these waters meeting applicable water quality standards? We provide quality assured data via the Ecology website and by request (record extends to 1973).

Approach:

We collect monthly data from about 40 core & rotational stations to determine spatial, seasonal and interannual patterns in marine water quality. We measure water physical and chemical properties (temp., salinity, density, pH), biologically related variables (chlorophyll, nutrients, DO, water clarity) and fecal coliform bacteria. When persistent water quality problems are identified, we begin intensive studies to identify causes and sources, including the development and application of circulation and water quality models to guide management actions.

Indicator Uses:

Two multiple parameter indices have been developed:

Water Quality Concern Index – sites of highest concern have fecal contamination, low DO, high ammonium, low dissolved inorganic nitrogen & strong and persistent stratification.

Sensitivity to Eutrophication Index – most sensitive sites have low dissolved inorganic nitrogen, low DO & strong and persistent stratification.

Recent results: http://www.ecy.wa.gov/programs/eap/mar_wat/presentation_maloy_gbps_07.pdf

Related Regulations, Policies, and Initiatives:

Data generated through this component are used for implementation of the Clean Water Act through water quality assessment listings (303d) and reporting requirements (305b).

Major Accomplishments:

- South Puget Sound Dissolved Oxygen Study: Initiation of intensive data collection and modeling program in order to explain causes and distribution of low DO. A report on wind-driven circulation in this basin was recently released. www.ecy.wa.gov/biblio/0703033.html
- Establishment of 3 near-shore, bottom-mounted moorings in Puget Sound. Real-time data is available from the NANOOS website. <http://www.ccalmr.ogi.edu/nanoos>
- Founding and continuing partner in the JEMS program (Joint Effort to Monitor the Strait of Juan de Fuca) established to characterize seawater moving in and out of Puget Sound (ocean boundary conditions). Maintenance of the JEMS database.
- Monthly monitoring of water quality identified low DO as a chronic problem in Hood Canal, leading to the initiation of the Hood Canal Dissolved Oxygen Program.
- Intensive study in Willapa Bay to characterize conditions and nutrient inputs including primary productivity studies. Collection of continuous data at 4 surface-floating moorings since 1997.
- Generated dozens of reports, posters, and presentations summarizing the condition of water quality throughout Puget Sound and the coastal estuaries, available via the web or by request.

Marine Waters Monitoring - PRISM

PRISM, University of Washington

<http://www.prism.washington.edu/>

Purpose/Questions Addressed:

- Document the interannual, seasonal, and spatial variation in water physical properties (temp., salinity, density) and other biologically related variables (oxygen, nutrients, chlorophyll, light penetration and transmission, and primary production).
- Assess affect of climate and other external forcing on properties.
- Provide a database of primary production as well as an assessment of phytoplankton growth sensitivity to added nutrients in the diverse areas of Puget Sound, as a means of assessing vulnerability to human eutrophication.
- As a partner of JEMS, continue to provide an assessment of ocean boundary conditions and input into the Strait of Juan de Fuca.
- Provide data to public via PRISM/PSMEM websites.
- Provide opportunity for student training and education, as well as data for research.

Approach:

- Analysis and publication of observational results.
- Incorporation of data into numerical models.
- Participation in two cruises annually.

Indicator Uses:

Data are collected in the same manner as WDOE, but not on same time-scale (2x/y not 12x/y).

However, the data provide a synoptic view of Sound which is not available from WDOE monitoring

The best utility of this type of data is for model inputs/verification and for assessing climate influence.

Several analyses and manuscripts have been produced.

Related Regulations, Policies, and Initiatives:

PRISM is a University of Washington Initiative. It does not have any regulatory authority. Its goals are to enhance scientific understanding and research on Puget Sound, promote education and provide data and tools that can aid regional decisions. Examples of where PRISM has contributed information to regional planning decisions can be found on the PRISM website.

Major Accomplishments:

- Contributed to understanding of Hood Canal hypoxia via oxygen inventory.
- Allowed construction and operation of circulation models.
- Provided basis for several manuscripts and analyses of climate impacts on Puget Sound water properties.
- Provided basis for research on phytoplankton production, speciation, and transport.
- Provided input to regional planning on a variety of projects, including siting of the KC outfall, salmon-watershed practices, and is currently informing the HCDOP study on Hood Canal hypoxia.

Nearshore Habitat

Aquatic Resources Division, Washington Department of Natural Resources

<http://www.dnr.wa.gov/htdocs/aqr/nshr/index.html>

Purpose/Questions Addressed:

- What are the status and trends in key components of nearshore habitat in Puget Sound?
- What is causing the observed patterns of change?

Approach:

The Nearshore Habitat Program conducts multiple monitoring, research and mapping projects. We distribute results through regular reports, peer-reviewed publications, and digital data:

- *Submerged Vegetation Monitoring Project (SVMP)* – conducts annual surveys of eelgrass abundance throughout greater Puget Sound.
- *Eelgrass Stressor-Response Project* – investigates stressors causing observed eelgrass losses.
- *Kelp Monitoring (Olympic Peninsula)* – conducts annual surveys of floating kelp distribution and abundance along the Strait of Juan de Fuca and the outer coast.
- *Kelp Monitoring (greater Puget Sound)* – surveys canopy-forming kelp distribution and abundance over Puget Sound and relates findings to historical information.
- *Intertidal Biota Monitoring* – conducts annual monitoring of intertidal biota on beaches in central and southern Puget Sound.
- *Habitat Inventory* – produces digital information characterizing nearshore habitats, including the state-wide ShoreZone Inventory and multiple regional inventories.

Indicator Uses:

- Eelgrass monitoring results are the basis for the Puget Sound eelgrass area indicator that has appear in various reports, including the *State of the Sound*, *Puget Sound Update*, and DNR reports.
- Results from the kelp monitoring are the basis of an annual kelp abundance indicator reported by DNR. Data is distributed freely and used by multiple organizations.
- Habitat inventory information is used widely for multiple indicators that describe extent of shoreline alteration, physical shoreline characteristics, and distribution of vegetation.

Related Regulations, Policies, and Initiatives:

Nearshore habitats receive special protections by the state:

- Habitat of special concern under HPA authority (RCW 77.55.100).
- Critical habitat under Shoreline Management Act authority (RCW 90.58).
- WDFW has a policy of no net loss in eelgrass habitat.
- DNR is charged to ensure environmental protection and other public benefits (WAC 332.30.100)

Major Accomplishments:

- Produced the ShoreZone Inventory, the primary nearshore information source for local shoreline plans, regional recovery plans such as the Shared Strategy for Salmon Recovery, restoration by the Puget Sound Nearshore Partnership, and ecoregional assessments by the Nature Conservancy;
- Documented that one-third of all shorelines have been altered by bulkheads and alterations.
- Found that sites with eelgrass losses have consistently outnumbered those with gains since monitoring began in 2000. Areas of greatest concern include Hood Canal and the San Juans.
- Initiated collaborative research program into causes of eelgrass declines.

Toxics in Biota

Washington Department of Fish and Wildlife (DFW)

<http://www.wdfw.wa.gov/fish/psamp/>

Purpose/Questions Addressed:

- What is the extent and magnitude of exposure of Puget Sound's (PS) living resources to toxic contaminants?
- How is this exposure changing through time?
- What are the effects of exposure to toxic contaminants (collaboration with NOAA)
- What is the risk to humans from consuming PS seafood (DOH lead, using DFW data)

Approach:

DFW measures exposure of key (indicator) species for a range of toxic contaminants at fixed index sites and various focus or assessment sites throughout Puget Sound. Exposure to toxics in these fish is assessed by measuring contaminants directly from fish tissues, metabolites of contaminants in fish, and health-effects, such as cancer or reproductive impairment.

Indicator Uses:

All indicators served by these data relate to exposure of fish and shellfish to toxic contaminants, effects on organisms from this exposure, and potential exposure of humans to toxics from consuming contaminated fish. A fully implemented¹ toxics monitoring program includes:

- Time trend indicator (whether conditions are getting better or worse)
- Geographic trend indicator (how extensive is the contamination)
- Emerging toxics indicator (what new toxics are infiltrating the food web)
- Reproductive impairment related to endocrine disruptors
- Liver cancer related to exposure to hydrocarbons (location-specific relationship between contaminated sediments and bottomfish disease)
- PCBs and mercury Puget Sound Seafood

Related Regulations, Policies, and Initiatives:

The overarching initiative served by this activity is the Governor's Puget Sound Initiative:

- Help to identify areas of greatest concern and to prioritize cleanup or remediation efforts,
- Evaluate effectiveness of management efforts to clean up or prevent toxics, and
- Highlight the value of preventing toxics from entering the system.

Major Accomplishments:

- Review of time trends in PCBs in English sole, coho salmon and Pacific herring
- Evaluation of biota as a reservoir of toxics
- Evaluation of salmon as prey-vectors of PCBs to Killer Whales
- Journal article describing spatial patterns of toxics in Pacific herring: **Spatial extent, magnitude, and patterns of persistent organochlorine pollutants in Pacific herring (*Clupea pallasii*) populations in the Puget Sound (USA) and Strait of Georgia (Canada).**
In press, Science of the Total Environment

¹ the Toxics in Biota component is currently funded at approximately 64% of its full implementation

PSAMP CONTACTS AND PUBLICATIONS

PSAMP monitoring results are integrated, summarized, and presented in the *Puget Sound Update* (www.psp.wa.gov/puget_sound/update.htm). Findings are also presented every two years at the *Puget Sound/Georgia Basin Research Conference* (www.engr.washington.edu/epp/psgb/).

PSAMP scientists regularly provide additional, detailed information on their monitoring efforts and results. Contacts and links to these scientists and their work are listed below:

Marine Waters and Sediments

- ▶ WA Department of Ecology www.ecy.wa.gov/programs/eap/psamp/
www.ecy.wa.gov/programs/eap/psamp/mar_wat/mwm_intr.html
- ▶ King County Dept Natural Resources www.dnr.metrokc.gov/wlr/waterres/marine/

Freshwater

- ▶ WA Department of Ecology www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html

Birds and Fish Abundance

- ▶ WA Department of Fish and Wildlife wdfw.wa.gov/wildlife.htm
wdfw.wa.gov/science/
wdfw.wa.gov/mapping/psamp/

Toxics in Fish and Wildlife

- ▶ WA Department of Fish and Wildlife wdfw.wa.gov/fish/psamp/
- ▶ NOAA Fisheries www.nwfsc.noaa.gov/index.cfm
- ▶ US Fish and Wildlife Service westernwashington.fws.gov/contaminants/
- ▶ US Environmental Protection Agency www.epa.gov/region10

Shellfish

- ▶ WA Department of Health www.doh.wa.gov/ehp/sf/sfpubs.htm#GrowingAreasPubs

Nearshore Habitat

- ▶ WA Department of Natural Resources www.dnr.wa.gov/htdocs/aqr/nshr/

Hood Canal

- ▶ Hood Canal Dissolved Oxygen Program www.hoodcanal.washington.edu/
University of Washington

Puget Sound Regional Synthesis Model

- ▶ University of Washington www.prism.washington.edu/



PSAMP
working towards a...



fishable...



swimmable...



diggable...

...Puget Sound.

